The Muscular System

Three types of muscle

- Skeletal muscle- attaches to and moves bone
  - is striated
  - is voluntary
- Smooth muscle- located in the walls of internal structures
  - non-striated
  - Involuntary
- Cardiac muscle

Functions of Muscle Tissue

- Motion
- Movement of substances within the body
- Stabilizing body position and regulating organ volume
  - maintaining posture
  - maintaining food storage in stomach
- Heat production
  - muscle contraction generates 85% of the body's heat

Characteristics of Muscle Tissue

- Excitability- receive and respond to stimuli
- Contractility- ability to shorten and thicken
- Extensibility- ability to stretch
- Elasticity- ability to return to its original shape after contraction or extension

General Anatomy of Skeletal Muscle

- **origin**- stationary end of muscle attachement
- **insertion**- mobile end of attachment
- **belly**- thicker middle region

Structure of Skeletal Muscle

Connective tissue components

- fascia- sheets or bands of fibrous c.t. around organs, muscle and beneath the skin
  - **superficial fascia** (subcutaneous layer)- composed of areolar c.t. and adiose tissue and is located under the skin
  - **deep fascia-** composed of dense, irregular c.t. that holds muscles together and from which the various subdivisions of muscle c.t. are derived

Production of ATP in Muscle Fibers

- Muscles have three ways to produce ATP
  - from creatine phosphate-unique to muscle tissue
  - anaerobic cellular respiration using glycogen
  - aerobic cellular respiration using glycogen, fatty acids, and amino acids

Energy for Contraction

•ATP- immediate source of energy that last for only 5 seconds

•Creatine Phosphate- high energy molecule that is used to make ATP.

–Makes enough energy to last for about 15 seconds

•Glycogen- storage form of glucose

–with oxygen can use the glycolytic-Krebs cycle pathway to produce ATP (aerobic respiration)

•most efficient method of energy production

–without oxygen can use glycolytic pathway with end product of lactic acid (anaerobic respiration)

•can provide enough energy for 30 seconds of maximal activity

All or None Principle

•Threshold stimulus- the weakest stimulus from a neuron that can still initiate a contraction.

•All-or-none principle- when stimulated, a motor unit will contract to its fullest; a motor unit cannot partially contract.

–When a whole muscle contracts, not all motor units are contracted. The more strength that is needed, the more motor units that are recruited.

Muscle Tissue and Homeostasis

•Oxygen Debt

–during exercise, the muscles must have an increased supply of oxygen

•blood vessels dilate and blood flow increases

–when muscular exertion is to great, oxygen cannot be supplied to the muscles fast enough, resulting in the conversion to anaerobic respiration. This causes a build up of lactic acid.

–After exercise stops, extra oxygen is required to

•metabolize the lactic acid

•replenish ATP, creatine phosphate, glycogen

•pay back oxygen borrowed from hemoglobin, lungs, myoglobin, and body fluids

–Oxygen debt is paid back by labored breathing after exercise is stopped.

•The accumulation of lactic acid causes hard breathing and enough discomfort that to stop muscle activity until homeostasis is restored.

Muscle Tissue and Homeostasis

•Muscle Fatigue- the inability of muscles to maintain its strength of contraction

–related to

•insufficient energy

•insufficient oxygen

•depletion of glycogen

•build up of lactic acid

–lactic acid increase causes a decrease in the pH (increase in hydrogen ion concentration)

–thus, muscle fatigue is viewed as a homeostatic mechanism to prevent pH levels from dropping below the normal acceptable range for the cellular environment.

•Heat Production-

– 85% of the energy of muscle contraction is given off as heat to help maintain body temperature.

- shivering when cold

Kinds of Muscular Contraction

Twitch Contraction- a brief contraction of all the muscle fibers in a motor unit in response to a single action potential.

- Four phases
  - latent period- calcium is released from the sarcoplasmic reticulum and myosin head activity begins
  - contraction phase
  - relaxation phase
  - refractory period- period of lost excitability (cardiac muscles have a long refractory period)

Kinds of Muscular Contration

Tetanus- sustained muscle contraction

- incomplete tetanus- when concurrent stimuli is applied such that the muscle only partially relaxes (wave summation)
- complete tetanus- stimuli is applied such that the muscle does not relax all
  - most muscle action is of this type

Kinds of Muscular Contraction

Isotonic Contraction- the muscle shortens and pulls on another structure, such as bone.

- Tension remains constant and energy is expended

Isometric Contraction- there is minimal shortening of the muscle.

- Tension increases greatly and energy is expended
  - holding a book out to the side

Kinds of Muscular Contraction

- Two forms of isotonic contraction
  - **concentric contraction**- when a muscle shortens as it maintains tension as when the biceps contract and flexes the elbow
  - **eccentric contraction-** a muscle lengthens as it maintains tension as when your biceps lengthens as you extend your elbow

Physiologic Classes of Muscle Fibers

- Not all muscle fibers are metabolically alike
  - **slow oxidative, slow twitch, red, or type I fibers-** respond slowly but are relatively resistant to fatigue
    - soleus muscle of the calf and the postural muscles of the back
  - **fast glycolytic, fast twitch, white or type II fibers-** respond more quickly but also fatigue quickly
    - gastrocnemius, biceps brachii, muscles of eye movement

Muscle Tone

(tonus= tension)

A sustained partial contraction of portions of a muscle

- Hypotonia- decreased or loss of muscle tone (flaccid)
- Hypertonia- increased muscle tone and is characterized by muscle stiffness.

Muscular Atrophy

Individual muscle fibers decrease in size owing to a progressive loss of myofibrils (wasting away)

- disuse atrophy- the flow of impulses to inactive muscle is greatly reduced.
- denervation atrophy- complete atrophy when the nerve supply is cut. (6 mo.-2yrs. muscle 1/4 original size)
  - the muscle is eventually replaced by fibrous tissue (irreversible)

Muscle Hypertrophy

Increase in the size of muscle fibers secondary to increase in myofibrils, mitochondria, SR, nutrients, and energy supplying molecules.

- muscle size controlled by growth hormone, testosterone, and exercise.

Cardiac Muscle

- involuntary
- striated
- have only a single centrally located nuclei
- exhibit branching

Consist of two separate networks:atria and ventricles

- fibers in each network are connected to each other via **intercalated disks** (irregular transverse thickening of the sarcolemma).
- the discs contain **gap junctions**, which conduct muscle action potentials from one fiber to the other. This enables each network to conduct as a unit.

Cardiac Muscle Fiber characteristics

- contracts continuously without stopping
  - requires a constant supply of energy and oxygen
- fibers can contract without nervous stimulation (autorhythmicity)
  - is stimulated by a pacemaker and a specialized conduction tissue.
  - nervous stimulation only modulates contractions.
  - pacemaker fires at a greater rate than fibers,thus, establishing the contraction rate.
- has a long refractory period
  - prevents complete tetanus

Smooth Muscle

- Involuntary
- single centrally located nuclei
- nonstriated
- also has intermediate filaments as well as thick and thin myofilaments
  - intermediate filaments stretch between structures similar to z lines called **dense bodies**.

Contraction causes a length wise shortening of the cell.

Smooth Muscle

- Our bodies contain two types of smooth muscle, both of which are controlled by the autonomic nervous system.
  - **Multiunit smooth muscles-** are **found in large arteries**, around **hair follicles** (where they produce piloerection, or fluffing of fur), and in **the eye** (controlling lens adjustment and pupillary dilation).

–This type of smooth muscle is **normally inactive**, but it will **contract in response to neural stimulation or to certain hormones.**

Smooth Muscle

•Single-unit smooth muscles

–normally **contract in a rhythmical fashion**.

–the **efferent nerve supply** (and various hormones) **can modulate the rhythmical rate**, increasing or decreasing it, **but the contractions themselves occur independently**.

–are **found chiefly in the gastrointestinal system and uterus.**

Differences of Smooth Muscle From Striated Muscle

•**duration of contraction** is 5-500 times **longer**

•can **undergo sustained, long-term tone** (important in GI tract, vessels, bladder)

•**contraction can be in response to hormones or local factors**, such as pH, oxygen and CO_2, temperature, and ion concentrations.

•**can stretch considerably without becoming tense or taut** which allows smooth muscle to accommodate great changes in size while still retaining the ability to contract.